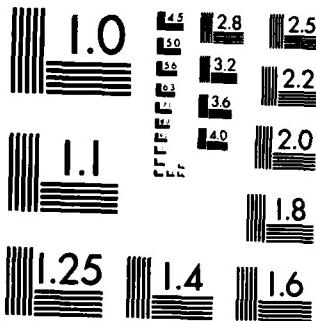


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AIRSICKNESS CONTROL USING BIOFEEDBACK TO SELF-REGULATE PSYCHOPHYSIOLOGICAL RESPONSES

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December 1984

Final Report for Period August 1979 - May 1982

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USAF SCHOOL OF AEROSPACE MEDICINE
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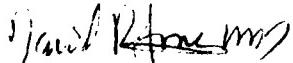
NOTICES

This final report was submitted by personnel of the Neuropsychiatry Branch, Clinical Sciences Division, USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, under job order 7755-26-04.

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The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.



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<p>/Investigators of the Neuropsychiatry Branch, Clinical Sciences Division, U.S. Air Force School of Aerospace Medicine (USAFSAM), provided biofeedback-moderated behavioral treatment to 53 fliers grounded for chronic, severe motion sickness, and followed each flier for 2 years after treatment completion. Success was defined as returning to and maintaining satisfactory operational flying status. Forty-two fliers (79%) met this criterion; three (6%) were partially successful, and eight (15%) were subsequently grounded for recurrent airsickness... Follow-on studies will investigate psychophysiological mechanisms through which this method of treatment works. ↗ Psychophysiology.</p>												
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AIRSICKNESS CONTROL USING BIOFEEDBACK TO SELF-REGULATE PSYCHOPHYSIOLOGICAL RESPONSES

INTRODUCTION AND BACKGROUND

From 10 to 38% of military student pilots experience airsickness (1-7), and have done so since aviation's earliest days. Although much effort and study have been devoted to its etiology and treatment, there is still no agreed-upon, standard, and dependable way of ameliorating airsickness in this group. Most who are affected lose their motion sensitivity as they continue to fly, but some do not. Medications such as dextroamphetamine-scopolamine or promethazine-ephedrine combinations may be prescribed for airsick U.S. Air Force student pilots, but solo pilots may not use these drugs because of potentially dangerous side effects. Thus, student pilots who do not adapt with the aid of medication in four or five presolo flights may be medically eliminated from further training.

Fliers other than pilots--such as student navigators, load-masters, refueling boom operators, gunners, and others--also may become severely airsick. Since these nonpilots may be faced with fewer demands as well as less rigorous observation than the student pilots, some continue their airsickness into operational flying and come to medical attention only when they fail to adapt to a new aircraft or flight profile several years later.

Because of the multiple missions of the Air Force and the variety of flying situations to which fliers may be exposed, no reliable records or statistics are kept of the incidence or prevalence of airsickness. Anecdotally, we hear that frank, active airsickness is not uncommon in navigators and radar navigators on B-52s, in weapons systems operators (WSOs) in F-4s and F-111s, and among aircrew on C-130s, especially on low-level missions. Even experienced pilots are not immune: we have treated airsick T-33, C-130, and C-141 pilots with 3 to 10 years' experience. Such aviators come to medical attention when they cross-train into a new aircraft, when an alert flight surgeon becomes aware of their problem, or when their motivation slackens and they decide they will no longer fly with their airsickness. This condition exists in all Major Air Commands (MAJCOMs), all aircraft types, and fliers of varied experience. Incidence and prevalence are unknown, as is effect on operational flying; but the loss of a student pilot at 15 hours represents over \$15,000, and a trained flier may represent over a half-million dollar loss.

Various attempts have been made to offer nonmedication treatment for chronic airsickness. Several programs have offered methods of adaptation or desensitization to Coriolis stimulation, using Bárány or tilt-spin chairs and some degree of supportive psychotherapy. Dobie, who had complete control of the Royal Air Force's airsickness rehabilitation program and had pilot physicians fly with the subjects during their final adaptation phase, reported an 82% rehabilitation rate (1). An unreported U.S. Air Force School of Aerospace Medicine (USAFSAM) protocol of the mid-1970s used incremental Coriolis stimulation and psychotherapeutic relaxation techniques including deep muscle

relaxation and calming imagery. Some 45% of the 35 aircrew accepted for that treatment program went back to operational flying, without airsickness, upon return to their base.

Money (4) and Preber (8), among others, have commented upon the contribution of anxiety to the incidence of airsickness. The extent of the contribution of this psychological component is difficult to determine quantitatively. Marsh and Rocco (9) have reviewed the influence of psychological factors in precipitating motion sickness symptoms. Although the incidence of these factors in a group of airsick fliers is not clear-cut, it may be considerable in a sensitized individual: the anticipation of motion stimuli may be enough to precipitate the symptoms of passive airsickness, if not frank vomiting. During a discussion with one of us (R.A.L.), a group of instructor pilots at Randolph Air Force Base unanimously agreed that the fear of failure or of poor performance is a primary cause of airsickness in student pilots.

Several medical researchers have demonstrated that autonomic nervous system responses can be overridden by voluntary control achieved through biofeedback training (10-14). These autonomic responses can be conditioned to a particular stimulus, such as voluntary peripheral vascular dilatation in response to the prodrome of a vascular (migraine) headache (15, 16). Cowings and her colleagues (17-19) have used autogenic training techniques coupled with biofeedback modalities to teach autonomic control and relaxation. These skills, once mastered in quiet surroundings, have consistently increased subjects' tolerance to motion stress under laboratory conditions, when compared with untrained controls. Anecdotal reports indicate that such training has also diminished subjects' susceptibility to motion sickness in sailboats, etc. (Cowings, personal communication). Cowings' approach trains volunteers in a static environment to use biofeedback to acquire techniques that are then used without feedback instrumentation to overcome artificially induced motion sickness produced by Coriolis stimulation. One test group was able to override the typical pallor, cold sweating, gastric awareness, and nausea by using the techniques of warming and relaxing (learned through biofeedback training). Of 50 subjects, 85% reportedly improved their ability to withstand motion stimuli, and 65% completely suppressed illness. An untrained control group of 60 showed no significant improvement with time.

Biofeedback training, then, may alleviate airsickness in at least two ways: by inhibiting involuntary autonomic responses to motion stimuli, and by allaying anxiety. Biofeedback training can diminish anxiety as the trainee learns to self-initiate a "relaxation response" (20) to motion stress, resulting in a lower rather than a higher state of autonomic arousal. This voluntary relaxation can also be taught as a response to stimuli that may be incidentally associated with airsickness, such as the smell or feel of an oxygen mask, thus providing a possible additional approach to the problem.

Traditionally, biofeedback training has been given in a warm, low-lit, quiet, low-stimulus environment, with soothing and relaxing surroundings and techniques. In 1979 we began the protocol reported here, which represents, to our knowledge, the first use of biofeedback instrumentation and training techniques in treating subjects referred for intractable airsickness and the first instance where relaxation techniques have been taught in a dynamic and challenging environment. The initial results obtained with the first 20

subjects were reported in 1981 (21); those 20 are included in this report which is a 2-year followup of all 53 subjects who completed the protocol.

SELECTION OF SUBJECTS

Base-level flight surgeons referred possible subjects to us after we announced the availability of this treatment protocol through letters to MAJCOM surgeons and announcements to classes of student flight surgeons. We stressed the importance of strong motivation to fly, as assessed by the local flight surgeon, the subjects themselves, and their instructors or supervisors. Prospective subjects deemed well motivated were referred to the Clinical Sciences Division of USAFSAM for a screening evaluation. At first each subject underwent a complete aeromedical evaluation. Later this provision was withdrawn, and prospective subjects underwent evaluations only by the Otolaryngology and Neuropsychiatry Branches. These began with a clinical evaluation of ears, nose, and throat, including audiometry and electronystagmography. A psychiatric interview followed which covered present situation, history of motion sickness, detailed description of onset and aftermath of motion sickness, measures taken to counter motion sickness, pertinent family history, origin of interest in flying, strength of motivation to fly, an assessment of other life stresses, and mental status evaluation. No psychological testing was done, though we now feel that this source of data could have been useful in our data analysis.

Once cleared medically, the potential subject was briefed on the protocol. Biofeedback is a remarkably safe treatment method, with very few possible contraindications: significant psychopathology, unsuspected and significant somatic symptoms that might be masked, or choice of biofeedback when other therapeutic modalities might be more appropriate (22). Examples might include (1) potentiation of psychotic episodes in prepsychotic subjects, (2) lowering of requirement for insulin and thyroid in diabetic and in hypothyroid patients, and (3) possible increase in sedation from medications with sedative effects. None of these conditions applied to any of our subjects, who were in the excellent physical status necessary to meet flight physical standards. Subjects were then given the opportunity to volunteer for the protocol, with the stipulation that they could withdraw without prejudice at any time. They were given a ride on the rotating chair on the Friday prior to beginning relaxation training, for orientation and for us to get an idea of the degree of their sensitivity. Thus we determined how much stimulation was necessary to produce motion discomfort similar to that caused by flying.

RELAXATION TECHNIQUES

Each subject was introduced to a variety of relaxation techniques before the rotating chair sessions began. First the subject had the opportunity to express any anxiety, misgivings, or ambivalence felt toward flying. We explained how anxiety about becoming motion sick contributes to actual motion sickness, and we described by way of comparison the familiar visceral effects of stage fright or preathletic contest anxiety. We emphasized the importance of the subject's full cooperation and active participation in forming a treatment partnership.

The subjects learned the rudiments of deep muscle relaxation using an abbreviated form of Jacobsonian contraction and slow relaxation techniques (23). A subject--placed in a quiet, darkened room and with temperature/GSR biofeedback equipment attached--was given about 1½ hours of relaxation training with biofeedback. All subjects were given a portable GSR unit to use during their stay and were instructed to practice the technique in their rooms twice a day, 20 minutes per session. Next we demonstrated diaphragmatic breathing, with the emphasis on a normal inhalation and a long, slow exhalation lasting at least 4 times the duration of inhalation. This, too, was to be practiced twice a day. Mental imagery of several types was introduced, e.g., the image of a relaxing, quiet outdoors scene.

A second type of imagery was used to blank out obtrusive thoughts. Mental images such as a geometric form (a colored dot, the letter H, the number 1) or a blank projection screen or blackboard were suggested as examples. These images would later be used to "clear the mind" if intrusive thoughts supervened or involuntary daydreaming began. Finally, the subject was instructed in physioanatomic imagery. This included imagining the appearance of heart, blood vessels, respiratory tract, muscles, stomach, and other parts in such a way as to "see" them functioning normally and to "see" them relaxing in response to the subject's intentional "instructions."

The role of relaxation in aborting motion sickness was explained and reinforced during subsequent sessions in the rotating chair. Simply stated, we told subjects that the cold, clammy feeling which accompanied the onset of motion sickness would not progress in people who knew how to keep themselves warm and dry, and that this skill could be learned by using the biofeedback instruments to acquire the skill of warming the hands and lowering the skin conductance response. We gave the subjects time to practice these various relaxation techniques with the portable GSR unit in their rooms over a weekend, and we generally began the actual biofeedback training in the Coriolis chair on the following Monday.

BIOFEEDBACK TRAINING PROCEDURE

Each subject was placed in a rotating chair that was built in-house to evaluate astronaut candidates during the early 1960s. We generally used counterclockwise rotation (though later in the training if the subject appeared to habituate, we changed the direction to clockwise). This chair was rheostatically controlled by the operator, with rotational rates up to 20 rpm. It could be tilted 40° to the left (inside the direction of rotation) or to the right (outside). The biofeedback instrumentation was mounted on a shelf approximately 0.46 m (18 in) in front of the subject, with remote readouts to the operator and to recording devices.

The biofeedback instrumentation included--

1. Skin surface temperature. This temperature, processed by the feedback instrumentation (J & J Thermal Model T-67), was taken by a ceramic bead thermistor taped to the distal fleshy aspect of the middle finger of the subject's left hand. Small changes in temperature were fed back in the form of an analog signal on a needle meter on the T-67. The T-67 was also

connected to a liquid crystal digital display (J & J Model D-30) that concurrently presented an instantaneous digital readout of the absolute skin temperature. The temperature also was available in the form of a vertical array of colored lights (J & J Model L-100 Light Column). This latter instrument malfunctioned during the treatment of our 12th subject, and since we had found that none of the subjects had opted to use this form of feedback, it was not replaced. Further, audio feedback was available through a headset, which some of our earlier subjects found to be too bulky and restricting and which interfered with our verbal instructions to them. This was replaced by a "bug-in-the-ear" receiver which left the other ear free to receive instructions. This latter system of audio feedback proved to be much more satisfactory. Thus, the temperature feedback was available to the subject in the form of analog meter indicating small changes; as a digital display of absolute temperature, mounted on top of the meter; and if selected, from an audio signal.

2. Skin conductance level and response. The skin conductance level (SCL) reflects the tonic level of perspiration-mediated electrodermal activity. The skin conductance response (SCR) reflects autonomically modulated phasic changes in electrodermal activity. This response was measured by electrodes strapped to the distal fleshy aspect of the second and fourth fingers of the subject's left hand, which were connected to the J & J GSR/SCR Model R-71 System. As with the temperature data, this information was presented in one of several ways: by a meter needle, by a liquid crystal digital display, and as an audio signal. Generally our subjects chose to use SCL/SCR audio feedback which provided them more information, in the form of short latency phasic SCR changes, than was available from the long latency, much smaller temperature changes.

3. Electromyographic data. Electromyographic (EMG) information was received from silver-silver chloride electrodes applied to the subject's forehead over the frontalis muscle. The two active electrodes were positioned in the standard forehead configuration (approximately 2 cm above each eyebrow with a reference electrode applied about 2 cm above the bridge of the nose). Muscle activity was then processed by a J & J Model M-55 Electromyographic System, which displayed EMG information to the subject on a meter and also as a liquid crystal digital display mounted above the meter. Although this information was useful as a measure of muscle relaxation with the chair at rest, rotation of the chair generated large electrical artifacts that significantly distorted the relatively small naturally occurring EMG changes. Thus we discontinued reliance on EMG data.

Temperature, SCL/SCR, and EMG were simultaneously presented in analog and digital forms to the operator by wiring that led through a slip-ring unit assembly mounted above the chair. Physiologic data from the feedback instrumentation was recorded on a polygraph (Grass Model 7). An event marker denoted the onset and duration of all challenges designed to elicit motion sickness symptoms. This polygraph record was useful in reviewing individual performance since the subject could see the psychophysiological responses made over an entire training session (and over several sessions) immediately upon session completion.

Each subject had approximately 20 sessions in the chair, each lasting 30-45 minutes twice a day for 2 work weeks, with one session in the morning and one in the afternoon. The first one or two sessions were used to allow the subject to become acquainted with the chair and to begin to achieve some measure of experimentation, familiarization, and control with the biofeedback equipment. As soon as the subject appeared to be at ease and the physiologic signals reached a stabilized resting level, slow rotation (no more than 5 rpm) was started to allow accommodation to the stimulus of the moving chair. When the subject was comfortable in the chair and when values had reached new baseline levels after beginning rotation, mild stimulation maneuvers were initiated. The following hierarchy of vertiginous stimuli was used: left chair tilt, right chair tilt, left/right chair tilt, right/left chair tilt. Once the subject could accommodate to these "passive" stimuli, active stimuli in the form of head tilts were added, again in a progressive hierarchy: left, right, left/right, right/left, and forward. Finally, forward body movements were introduced. These sequences were introduced at low rotation rates (5-7 rpm). Then, as the subject became more able to adapt to the most stimulating experience of the forward head tilt in a repetitive manner, the chair rotation rate was increased, usually in increments of approximately 2½ rpm. Although we set no specific goals for our subjects, they could usually tolerate the multiple head tilts at approximately 10-15 rpm by the end of the first week. The end point of tolerance was subjective: the patient assessed how much motion sickness was felt. We made no attempt to quantify this in any way other than a subjective assessment on a scale of 1 to 10, where 10 was frank vomiting and 1 was a state of nonarousal equal to the baseline when the subject first sat down in the motionless chair. Generally stimuli that produced subjective responses of 4-7 were optimal for progressive stimulus tolerance and achieving self-regulation. When a subject began to show habituation and accommodation to the stimulation, the rpm would be increased and/or challenges would be initiated closer together.

Typical serial sessions might proceed in the following manner: the patient would be placed at rest in the chair and would monitor the feedback signals until stabilized baselines were reached. These generally included a skin temperature of approximately 35°C (94-96°F), an EMG reading in the range of 4-7 mV, and a SCL reading in the range of 2-10 µmhos, depending on the subject's individual predisposition. The chair then would be rotated at 7½ rpm; and after the patient reequilibrated, a left chair tilt would be given. The subject might take approximately 2 minutes to bring activated physiologic levels back to baseline after this tilt. The tilt would then be repeated at approximately 2-minute intervals for three or four tilts. As these became less and less stimulating, right tilts would be given. These would be followed by the multiple chair tilts to the left and right in quick succession. After about 8-12 tilts, the patient most often would become tolerant of them and so would be instructed to begin forward head tilts. When these could be tolerated without undue difficulty (the patient returned to baseline within 30 seconds or so), the speed of the chair was increased and the series of stimuli reinstated. This series could require a few sessions to be completed; 10-15 stimuli constituted the optimal number of such challenges that a patient could tolerate within 30-45 minutes, especially during the early sessions. We took care not to induce frank vomiting; on the few occasions this did occur, the patient became sufficiently upset that recovery required more than 10 minutes.

In brief, we undertook to train the subject to be able to suppress nausea when it occurred, then to do this quickly (in 10 seconds or less), and then to do this quickly while thinking about something else (i.e., repeating emergency procedures, landing instructions, etc.). Although tolerance to Coriolis stimulation occurred, this was not the point of therapy. The point was to attain confidence in the newly learned skill of conscious suppression of nausea.

Fliers who had spoken of particular aversions to the smell of the oxygen mask, to jet fuel or exhaust odors, or to other aspects of the flight line were instructed to use mental imagery to expose themselves to these noxious stimuli while practicing their relaxation, using the principles of systematic desensitization (24). The fliers would gradually reintroduce themselves to the anxiety-provoking stimulus and use relaxation techniques whenever they became aware of anxiety. These situations were easily overcome in this manner. We would also instruct the fliers to "chair-fly" missions in their rooms and to report to us any portion of the "flights" that aroused their anxiety. Anxious feelings were also dealt with by use of clarification and desensitization. This included "chair-flying" missions while spinning in the chair, together with appropriate chair and head tilts and body movements. After completing about 20 such sessions, the subjects were returned to their flying units to apply these relaxation skills in the aircraft.

REORIENTATION FLIGHTS

Five reorientation flights were arranged for each flier, who would fly as an additional crewmember in order to be free of any crew duties or training demands. Thus the flier was free to experiment with relaxation techniques in flight and be satisfied that they could work in vivo. The first flight specifically was flown so as not to expose the flier to any motion stress. For student fliers, this would be a straight-and-level flight, with no aerobatics, hard turns, or overhead patterns. For crewmembers on larger aircraft, this would be an out-and-back or cross-country mission flown at high altitude, avoiding any low-level turbulence. After each of these graduated flights, designed to expose the flier to successively increasing degrees of motion stimuli, each flier reported to us by phone, often with the pilot in command or a student pilot's instructor on an extension phone. By the fifth flight, if all went well the flier would be "back on track" and ready to reenter operational flying at the appropriate level.

This method allowed us to make corrections or suggestions during the reentry process, especially if the flier encountered problems with motion sickness. We considered this a possibility, since some fliers had been grounded for 2 or 3 months before entering our program.

RESULTS

This report covers the period from August 1979 through June 1984. We evaluated 63 fliers for our protocol and accepted 55 of these for treatment between August 1979 and June 1982. We followed up each flier at the 1- and 2-year points after protocol completion. Fliers who went off flying status were usually not followed further, with one exception which will be described later. Ten fliers who were referred to us did not complete the protocol (Table 1), including the eight not chosen and two who did not complete the reentry flights. The lack of motivation in six of these fliers was notable when they were compared with the group as a whole. Three were moving in career directions which either did not require flying or in which it was a definite liability. Two had recently been transferred into aircraft that they disliked.

TABLE 1. FLIERS NOT SELECTED FOR OR NOT COMPLETING THE PROTOCOL

Rating	Aircraft	Age	Hours	Reason
1. Student Pilot	T-37	26	20	Medical - disqualified because of vertigo, cause undetermined
2. Navigator	B-52	29	1500	Motivation poor - planning to separate from Air Force in 6 months
3. Pilot (Foreign)	Super Mystere	25	1000+	Motivation poor - desired transfer into transports; this was recommended in place of therapy
4. Loadmaster	C-130	35	1550	Motivation poor - desired to cross train into C-5A; this was recommended in place of therapy
5. Senior Navigator	F-4	32	2600	Not currently on flying status - could not comply with protocol
6. Pilot	T-38	28	850	Motivation poor - nonvolunteer transfer from C-135s; wished to go to law school instead; did not volunteer for our protocol
7. Navigator	B-52	25	630	Medical - disqualified for claustrophobia; motivation also poor
8. Senior navigator	F-4	37	2000	Medical - disqualified for Mayo Grade III EEG abnormality; motivation also poor; recalled to cockpit against his will; would not have volunteered for our protocol if eligible
9. Student Pilot	T-37	27	15	Administrative - instructor pilot insisted that flier continue flying training while in reentry phase; airsick during this phase, and commander eliminated him before 5th ride
10. Electronic System Student Crewman	EC-135	24	160	First reentry flight lasted 7 h, with 2 h of very bumpy touch-and-go landings; subject had no control of flying environment and was very sick; refused further reentry flights and withdrew from training

The results of the protocol for the 53 fliers who completed treatment are listed in Table 2. Followup of the 26 student pilots who successfully controlled their airsickness yielded the following outcome: 5 are instructor pilots (3 in T-37s, 2 in T-38s); 4 are B-52 pilots; 2 each are flying C-141, KC-135 (one is a woman), F-4, and F-16 aircraft; and 1 each in a T-33, F-106, A-10, and C-130. Five of the 26 failed to complete pilot training for reasons other than airsickness: three for flying deficiency, one for manifestations of apprehension, and one for allergic rhinitis. Since they successfully reentered flying training without airsickness, these are regarded as successful outcomes for the purposes of this study.

Four of the eleven successful navigator/weapons systems operators (WSO) are currently flying in F-111s, three in C-130s, two in B-52s, and two in F-4s. The three successful pilots are in WC-130, C-141, and F-106 aircraft. One successful enlisted crewmember was a C-141 loadmaster who was grounded with multiple gallstones 3 months after returning to his base; this condition led to his medical retirement a year later. The other was a KC-135 boom operator whose airsickness did not recur, but who was grounded over a year later for manifestations of apprehension.

The three "qualified successes" warrant individual comment. The first was a Marine student pilot who returned to training after completing our protocol. He subsequently had recurrent airsickness during air-to-air combat maneuvers; but when he was transferred to heavy aircraft, he had no further trouble.

The second was an F-4 WSO who, upon return, could not adapt to the F-4 environment and had continued airsickness. He was transferred to C-130s and is now successfully flying transport missions.

The third was a C-130 loadmaster who was returned to flying in the C-130 and did well enough not to be grounded. However, the recurrence of airsickness on low-level missions led him to eliminate himself from flying duties 1 year later. Those three individuals adapted well enough to avoid medical grounding (our criterion for failure) and yet sought administrative relief for their symptoms.

TABLE 2. RESULTS BY FLYING CATEGORY

Category	Student pilot No. (%)	Pilot No. (%)	Navigator/ WSO No. (%)	Enlisted crew No. (%)	Total No. (%)
OUTCOME:					
Success	26 (76)	3 (100)	11 (84)	2 (67)	42 (79)
Qualified success	1 (3)	—	1 (8)	1 (33)	3 (6)
Failure	7 (21)	—	1 (8)	—	8 (15)
Total:	34 (100)	3 (100)	13 (100)	3 (100)	53 (100)

The eight failures included seven student pilots. Five were eliminated immediately after the five reentry flights. One (a woman) persevered for 15 sorties. Another flew for 65 hours before being grounded but has subsequently obtained a civil license, learned acrobatics, and so thoroughly overcome his airsickness that he has recently been readmitted to undergraduate pilot training and is doing well. The eighth failure was an Air National Guard F-4 student WSO who was unable to complete upgrade training in spite of the efforts of the Guard unit to help him adapt after his return.

These fliers covered a broad spectrum of flying missions and experience, from presolo student pilots to experienced fighter, bomber, and transport crewmembers. Although the interviewers expressed private doubts about the motivation of some who were treated, we found that the best approach was a frank discussion of the reasons why a given flier wanted to fly, combined with a conscious acknowledgement of any negative factor involved. Some who succeeded were initially mildly ambivalent, but they ultimately came down on the side of a decision to "give the program my best shot." The protocol was fatiguing and at times unpleasant, involving as it did 30 to 45 minutes of nausea-stimulating motion twice a day for 10 days. At the end of the protocol, several of our subjects spontaneously expressed their relief at being finished. None, however, experienced negative conditioning; i.e., the onset of anxiety or premonitory symptoms at the sight or sound of the chair. Many left with the confidence that if they had survived the chair, they could easily fly any mission profile!

Five therapists participated in this program (Table 3). The first two were in at the inception; therapist 2 left the School a year after the protocol began. Therapists 3, 4, and 5 joined the program later, upon their assignment to USAFSAM. Only therapist 1 was with the program from beginning to end. All five therapists were successful in applying this technique.

TABLE 3. RESULTS OF INDIVIDUAL THERAPISTS

Therapist:	1 No. (%)	2 No. (%)	3 No. (%)	4 No. (%)	5 No. (%)	Total No. (%)
OUTCOME:						
Success	19 (70)	6 (75)	9 (90)	5 (100)	3 (100)	42 (79)
Qualified success	3 (11)	-	-	-	-	3 (6)
Failure	5 (19)	2 (25)	1 (10)	-	-	8 (15)
Total:	27 (100)	8 (100)	10 (100)	5 (100)	3 (100)	53 (100)

DISCUSSION

This project has demonstrated that well-motivated fliers with chronic, severe airsickness who are refractory to other methods of treatment can be returned to unrestricted flying duties by using biofeedback-mediated self-regulation to enhance relaxation and to lower autonomic arousal once nausea occurs. Our application of this technique has included elements of biofeedback training, autogenic training, mental imagery, deep muscle relaxation, systematic desensitization, diaphragmatic breathing, and occasional brief psychotherapeutic interventions. Our goal has been to tailor a program to each flier's particular personality style and autonomic response pattern. The failure rate of only 15% attests to the effectiveness of this approach.

In the multiple single-subject clinical approach used in this study, each flier served as his own control. Treatment effects were compared with each subject's prior refractory response to a conventional treatment, which had led to his being grounded and referred to us as a last resort. Because of the vast differences in their prebiofeedback experiences, treatments, and expectations and in their different approaches to the training, the single-subject design seemed the most viable approach.

Each subject's progress through the protocol was paced according to that flier's subjective reports and the clinical impressions of the therapist. Some were overeager and had to be restrained from excessive Coriolis stimulation; others had to be more gently moved along over their passive resistance; a few had to be convinced that self-regulation through psychologic means was possible. These factors, coupled with the considerable differences in autonomic response patterning, made it impractical to provide uniform stimuli across an inflexible rotation schedule. Each subject's rate of progress was individually and clinically determined in cooperation with that subject.

The success of this treatment approach results from a combination of factors which at a minimum includes an accurate assessment of motivation, the use of biofeedback information, a therapeutic alliance between flier and therapist, and skill in providing the flier with a variety of relaxation techniques. Some who have discussed this program with us have asked about the interpersonal effects inherent in our strong interactions with our subjects. Such effects are unavoidable (scientifically) and highly desirable (therapeutically). This program works; and when expectation of success is communicated to the subjects, it helps lower their anxiety and thus their susceptibility to motion sickness (studied as nonspecific effects) (25, 26). It also bolsters the confidence that a flier must have in personal ability to relax and to interrupt the visceral response of nausea to a motion stimulus; without such confidence the flier simply would not relax. We see no way to teach this skill in a double-blind protocol in which no confidence is transmitted. Nor is it likely that this technique could be taught in a single-blind form, since this would give the therapist the difficult and possibly unethical task of communicating confidence in a technique known to be a sham.

Of necessity this treatment, and thus any incidental research, is and must be clinical and individual in its approach. The results demonstrate that these techniques enable a chronically airsick flier to control his or her own anxiety and to interrupt the autonomic components of early airsickness, thus continuing the flight without having symptoms progress to frank, disabling passive or active airsickness.

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